

TOXIC GASEOUS SUBSTANCES LIBERATED FROM HUMAN FECES DURING STORAGE

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Fecal masses may be a source of pollution of the cabin atmosphere of spacecraft by various toxic substances. The quantity of feces excreted per person per day averages 150-200 g depending on the character of the food and function of the gastro-intestinal tract [1, 2].

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The feces contain 65-75% water, 3.5% nitrogen, various lipids (lecithin, coprosterol), fatty acids, carbohydrates, and a small amount of neutral fats. They also contain certain mineral substances (calcium, phosphorus, magnesium, iron, etc.) and also decomposition products of bile pigments—stercobilinogen and fecal stercobilin [3]. Dead and living bacteria and fungi account for 25-30% of the dry weight of the feces.

Fecal masses are a good nutrient medium for microorganisms. As a result of their activity, the fecal masses are decomposed with the liberation into the atmosphere of toxic and foul-smelling substances such as: ammonia and aliphatic amines, methane, hydrogen sulfide and mercaptans, indole, skatole, fatty acids (acetic, lactic, butyric, propionic, etc.), phenol and other substances [3-5]. Depending on the conditions under which fecal masses are kept, and on certain other factors, the quantity of toxic substances liberated varies. According to A. V. Palladin [6], for example, during fermentation of feces under aerobic conditions, as a result of fermentation of carbohydrates the liberation of certain organic acids (acetic, lactic, etc.) into the atmosphere is increased. Under these conditions the liberation of carbon dioxide, methane, hydrogen sulfide, indole, skatole, ammonia and its compounds also is increased. Hence, the chemical composition of the gaseous substances entering the atmosphere in the process of keeping of fecal masses is in general known.

However, there is practically no information on the quantity of the main gaseous toxic substances liberated and on changes in the normal microflora of the feces during storage. The present investigation was carried out to study these matters. At the same time, the effect of chemical conservation of feces on the intensity of liberation of the principal toxic substances was also studied. Two series of experiments were performed for this purpose. In the experiments of series I certain toxic substances liberated into the surrounding medium from fresh feces at a temperature of 18-20° were determined. The fresh feces were placed in hermetically sealed exsiccators with a capacity of 8 liters. Ammonia and its compounds, hydrogen sulfide, mercaptans, phenols, volatile organic acids, indole and skatole were determined in the air of one of these exsiccators. By means of a blower, air from the exsiccator was drawn through a special system of chemical absorbents. As the air pressure in the exsiccator was reduced, air from the room, preliminarily purified in columns with solid alkali, silica gel, pumice soaked in sulfuric acid, and hopcalite, entered it. The inlet tubes into

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the exsiccator were so arranged that the feces lay in the path of the purified air. The process of withdrawing samples lasted 2 h.

The second exsiccator was kept closed for 2 h (to obtain comparable results). Next, air was withdrawn from it into evacuated receivers for subsequent determination of carbon monoxide, hydrocarbon, oxides of nitrogen, oxygen and carbon dioxide.

The toxic substances were estimated by standard chemical methods used in industrial hygiene [7]. The contents of toxic substances were expressed per 100 g fresh feces. The results of the experiments are given in Table 1.

TABLE 1. Liberation of Toxic Substances from Fresh Feces (mg/100 g)

Ammonia and aliphatic amines	Mercaptans and hydrogen sulfide	Phenols	Indole and Skatole	Fatty acids	Oxides of nitrogen, calculated as N ₂ O ₅	Hydrocarbons calculated as CH ₄	Oxides of carbon
0,052	Traces	0,011	0	Traces	0,037	0,120	—
0,035	—	0,009	0	—	0,005	0,248	0,023
—	0	0,007	0	0,079	0,042	1,780	0,081
—	0	0,006	0	0,138	0,008	0,696	0
0,008	Traces	0,013	0	0,111	0,009	0,173	0
0,062	»	0,010	0	0,155	Traces	0,696	0
0	»	—	0	0	0,078	—	0,170
0	0	—	0	0,203	0,094	—	0,494
0,011	0	0,011	0,037	0,310	0,236	1,230	0,330
0	Traces	0,006	0,008	0,846	0,123	1,480	0
0	0,113	—	0,013	0,500	0,007	—	—
Mean 0,019	—	0,009	0,002	0,259	0,061	0,802	0,122

Commas represent decimal points.

Table 1 shows that the content of substances determined in each of the 11 experiments showed considerable variation, presumably associated with the character of the diet and the composition of the bacterial microflora of the intestine in different subjects.

At the same time, the results show that large quantities of hydrocarbons, volatile organic acids, oxides of nitrogen, ammonia, carbon monoxide, and phenols are liberated from fresh feces during the first 2 h of keeping. Mercaptans and hydrogen sulfide were found only in traces. Indole and skatole were detected episodically.

TABLE 2. Effect of Conservant on Liberation of Toxic Substances from Feces When Kept for 5 days

Quality of Toxic Substances Liberated from Feces, mg/100 g															
Group	Ammonia and aliphatic amines	Mercaptan and hydrogen sulfide	Ketones	Indole and skatole	Fatty acids	Sulfur dioxide	Phenols	Aldehydes	Oxygen of nitrogen expressed as N ₂ O ₅	Carbon monoxide	Hydrocarbons expressed as CH ₄	Number of microorganisms/g feces			
	Without conversation	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	1. 2. 3. 4. 5. Mean	On first day of experiment			
												Aerobes	Anaerobes	Aerobes	Anaerobes
Without conversation	0,006	Traces	0,018	0,009	0,184	0,041	0	Traces	0,876	0	0,945	16·10 ⁷	8·10 ⁷	9·10 ⁸	7·10 ⁸
	0,238	0	0,011	0,005	0,136	0	0,0430		0,012	0	0,315	35·10 ⁶	2·10 ⁸	4·10 ⁸	2·10 ⁸
	0,375	Traces	0,014	0	0,078	0,006	0,008		0,074	0,063	2,630	8·10 ⁷	6·10 ⁸	3·10 ⁸	8·10 ⁸
	—	0	0,010	0	0,015	0	0,0440		0,035	0	0,552	6·10 ⁸	2·10 ⁸	8·10 ⁷	3·10 ⁸
	0,049	Traces	0,002	0	0,120	0,005	0		—	0,051	0,964	7·10 ⁶	6·10 ⁷	—	—
	0,167	—	0,010	0,003	0,107	0,010	0,0190		0,242	0,023	1,081	—	—	—	—
With conversation	0,197	0	0,020	0,006	0,069	0	0,0280		0,038	0,208	0	10·10 ⁸	17·10 ⁷	25	0
	0,009	0	0,007	0	0,428	0,012	0,0090		0,037	0,423	0,191	19·10 ⁷	25·10 ⁷	320	0
	0	Traces	0,035	0	0,100	0,046	0,0060		0,016	0,243	0,152	6·10 ⁸	13·10 ⁷	130	0
	0	»	—	0	0,130	0	0,0130		0,033	—	1,890	3·10 ⁷	7·10 ⁸	25	4
	0,019	0	0,004	0	0,078	0	0		0,023	0,207	0,630	5·10 ⁸	1·10 ⁹	19	0
	0,045	—	0,017	0,001	0,161	0,012	0,011—		0,023	0,270	0,573	—	—	—	—

Commas represent decimal points.

The experiments of series II were carried out with feces stored in hermetically closed exsiccators for 5 days at a temperature of 18-20°. At the end of this time, the ammonia, mercaptans with hydrogen sulfide, phenols, indole with skatole, sulfur dioxide, ketones, aldehydes, oxides of nitrogen, carbon monoxide, and hydrocarbons were determined in the air of the exsiccators.

In addition, before the beginning of the experiment and after its end the total number of microorganisms in the fecal masses of the anaerobic and aerobic groups was determined.

To prevent putrefaction and fermentation in the feces, and also for disinfection of them, experiments were carried out with chemical conservation of the feces. Copper salt V, which in our preliminary experiments completely inactivated the microflora in fecal masses in a dose of 8-10 g/100 g/8, was chosen as the conservant. The results of these experiments are given in Table 2.

Comparison of the results shown in Tables 1 and 2 (without conservation) show that during prolonged keeping large quantities of ammonia and nitrogen-containing substances are liberated from feces. The mean quantity of phenols, indole with skatole, organic acids and hydrocarbons liberated from fresh feces was practically the same as that liberated from feces stored for 5 days.

The total number of microorganisms was increased slightly in feces kept without conservant, mainly on account of the aerobic group.

Experiments using conservant showed a sharp decrease in the number of microorganisms, in most cases no anaerobes being found, while the aerobes had died in 99.99% of cases. Determination of toxic substances showed that the effect of conservation was to reduce sharply the liberation of ammonia and oxides of nitrogen (by 4 and 10 times respectively), indicating that the conservant suppresses putrefaction and fermentation processes.

The content of phenols, indole with skatole, fatty acids, sulfur dioxide and ketones remained at approximately the same level as in the background experiment.

The considerable increase (by about 10 times) in the quantity of carbon monoxide liberated from feces when kept with conservant must be noted.

Conservants such as copper salt V are known to give rise to energetic oxidation of organic substances composing feces [9-11]. In this case the carbon monoxide is probably a product of these processes. It may thus be postulated that the liberation of toxic substances during storage of fecal masses with conservant may be considerably reduced only when the conservant presses the aerobic and anaerobic microflora, but also inhibits oxidation of organic matter.

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